NEW JERSEY

AGRICULTURAL COLLEGE

Experiment Station.

70.

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AGRICULTURAL COLLEGE EXPERIMENT STATION.

BULLETIN 70.

JULY 26, 1890.

Some Fungous Diseases of the Spinach.

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Spinach is extensively grown in many parts of New Jersey for the New York and Philadelphia markets, to say nothing of those of the large cities within her own borders, like Camden, Trenton, Paterson, Jersey City and Newark.

During the past winter there have been loud complaints of a partial or almost complete failure of the crop, and while the conditions, namely, extreme warmth and moisture of the season, have been against the successful culture of spinach, there are other reasons for the trouble that it is the purpose of this bulletin to briefly set forth.

The forced spinach interests us more particularly in the present consideration of the fungous diseases of the crop. The outdoor spinach, at the time of writing, has the appearance of health. That under glass sickened and died in many cases before it was half large enough for market. One large grower, for example, informs me that counting only his labor, he will not realize more than fifty per cent. of what it has cost him. Besides this, there is the loss which is entailed upon coming years from placing a poor quality of product upon a market that is already a critical one because of the sharp competition of spinach grown out of doors and shipped from the Southern States. This failure has been attended by one or more forms of fungi, to be enumerated in the subsequent pages of the bulletin.

1. THE SPINACH MILDEW.

(*Peronospora effusa*, Rabenh.)

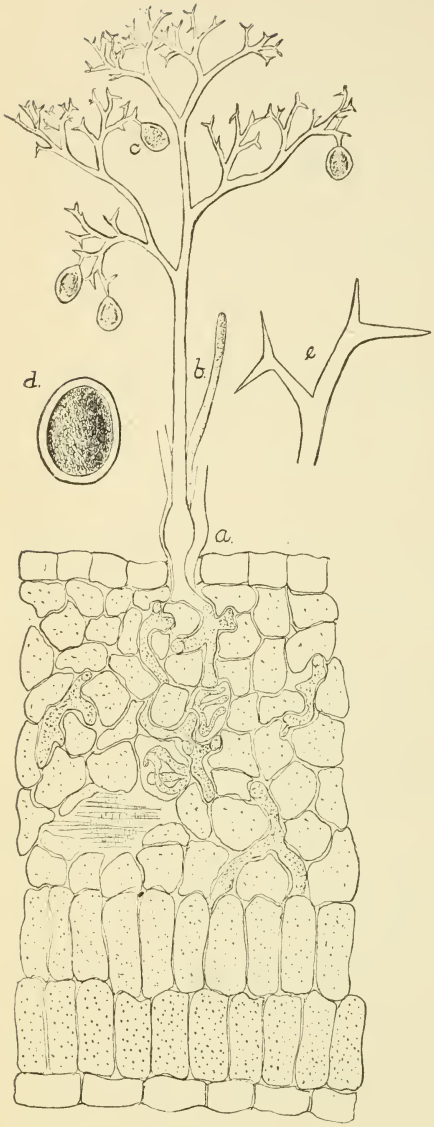

Figure 1.

A view of leaf section, showing the spinach mildew. *a*, Breathing pore, through which the threads pass; *b*, A young thread; *c*, Spore in position; *d*, Spore more enlarged; *e*, Tips of branches more enlarged.

In the mildew of the spinach, we have a member of a very destructive genus. Among its close of kin are the grape mildew, the mildew of the lettuce, especially of the greenhouse, the onion mildew, and others, some of which, by growing upon and injuring various weeds, may be considered as the friends of the farmers and gardeners. The spinach mildew grows quite commonly throughout the United States upon several kinds of weeds, known as the goosefoots, or lamb's quarters, all of which are closely related to the spinach. Among the mildews it is not unusual to find that several closely related plants will be subject to the same fungous disease. It is, however, interesting to note in connection with the mildew in question, that it, according to some authorities, flourishes upon such widely separate plants as the violets and smartweeds. Endeavors to grow the spinach mildew upon the cultivated violets under bell-jars, in the laboratory windows, have not, thus far, established the identity of the mildew upon these widely related plants.

In general appearance, to the naked eye, the spinach mildew produces gray, slightly violet, patches of a velvety texture upon the under side of the leaves, while from the upper side they have a pale yellow shade, due to the loss of the green color. The microscope is necessary for the satisfactory study of this trouble of the spinach. In Figure 1 is given a view of a thin section, taken with a razor, through a mildewed leaf. For convenience, the lower edge of the leaf is shown uppermost, so that the mildew may appear in an upright position. It will be seen that the mildew fungus consists of slender threads that grow throughout the substance of the leaf and afterwards certain tips pass out through the breathing pores and then branch into a somewhat tree-like structure, bearing the spores as oval bodies upon the tips of the ramifications. There is much variation in the branching of the tree-like top, but the spores are quite constantly of the same size and shape. It is to be borne in mind that the mildew is a little plant and the spores are to serve the same purpose as do the seeds for flowering plants. These spores, when they are ripe, easily become detached, and finding their way to a new leaf, cause another mildewed spot. In Figure 2 is shown the method of the branching of the filaments within the leaf. The particular tip of a branching

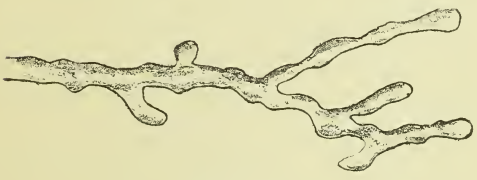

Figure 2.

The ends of a branching filament, as removed from the center of the leaf.

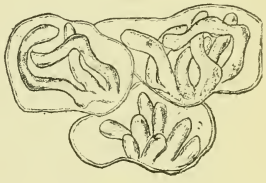

Figure 3.

Three cells of the spinach leaf nearly filled with "suckers."

thread was obtained by removing the surrounding substance by tearing with needles, or "teasing," as it is termed. As the threads become older they send out short branches, or "suckers," which enter the cells of the leaf to rob them of their nourishment. This is shown in Figure 3, where the cells, usually near the center of the leaf, are almost filled with these suckers.

As the spores germinate in various ways in the mildew group, the method for the one on the spinach was demonstrated by scattering some spores in pure water and leaving them for a few hours. Figure

4 shows how two of the spores produced slender tubes in much the same way as a seed develops a root under similar circumstances. The prolongations may enter through minute breathing pores of the leaf, after which the filament begins its branching, as shown in Figure 2, and the production of a new affected or mildewed spot.

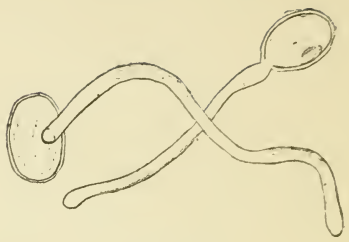

Figure 4.

Spores of spinach mildew germinating.

2. SPINACH ANTHRACNOSE.

(*Colletotrichum spinaceæ*, Ell. & Hals.)

This anthracnose of the spinach has been particularly destructive, and is a fungus of rapid growth, and therefore quickly spreads from one plant to another. It produces patches or blotches upon the leaves, at first small and inconspicuous. The first indication of its presence is an indescribable moist appearance of the, usually circular, affected part, followed by the appearance of minute brown pustules, while at the same time a gray color develops and the diseased area becomes dry. The anthracnose is shown in Figure 5, where an affected leaf, much reduced in size, is seen, with some portions killed by the fungus. No particular part of the leaf is first attacked, and therefore no two leaves appear alike. In some cases the largest leaves will be diseased; in other plants only the younger ones, but sooner or later plants that are affected will become entirely unfit for use. To test the rapidity of the growth of the anthracnose, healthy plants, grown in the laboratory, were inoculated with the spores, and in from five to seven days the spots sown had become thoroughly diseased, and were bearing multitudes of spores. In Figure 6 is shown a portion of one of the diseased patches, as seen with a

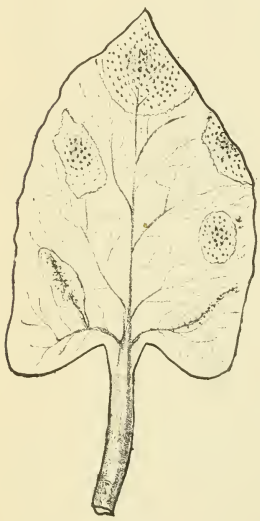

Figure 5.

Spinach anthracnose; leaf much reduced.

Figure 6.

Portion of anthracnosed leaf slightly magnified.

low power of the microscope. The fine threads of the anthracnose fungus, after ramifying through the leaf tissue, come to the surface at the breathing pores and pass out, forming the tufts of slender colorless threads. Here and there, in the hemispherical radiating patches, are stiff, dark, sharp-pointed, projecting, spine-like hairs, which are invariably present, but the particular use of which is not known to the writer. A more magnified view of one of these tufts is shown in Figure 7, in which the spores, as slightly crescent bodies, borne upon the tips of projecting threads, may be seen, with an occasional dark, sterile spine radiating from the common center of the tuft. In Figure 8 a similar formation is shown in side view, drawn from a section made through the spinach leaf. Here the relation of the tuft, the breathing spores and the tissues of the infested leaf become apparent at a glance. The anthracnose, unlike the mildew, has no great

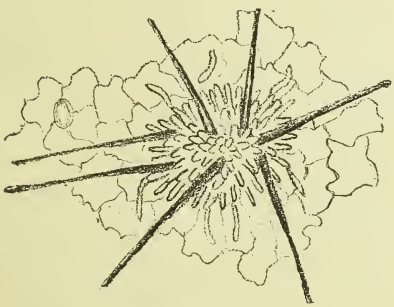

Figure 7.

An anthracnose tuft at a breathing pore.

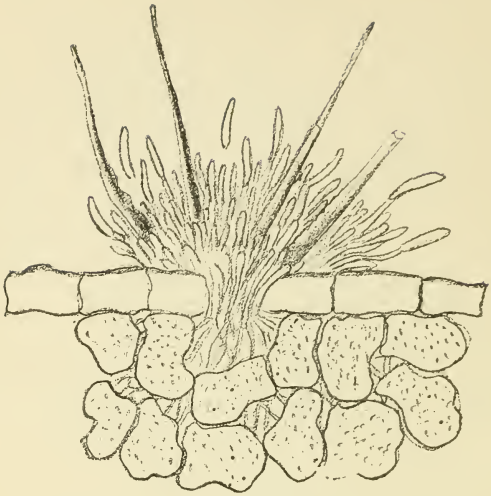

Figure 8.

Section through leaf, showing anthracnose fungus in side view.

preference as to the upper or under side of the leaf, and usually a diseased patch, even a small one, bears the spores upon both sides and in vast numbers, for there may be hundreds of rosettes distinct, or partly blended, upon a single square inch of surface. The spores, shown much enlarged at the left in Figure 9, germinate quickly by sending out a slender tube, as seen at the right hand of the same figure. Nothing of the history of this destructive fungus is known, for it is not mentioned in the books upon such subjects. It, however, has its near relatives in the anthracnose of the currant leaf, and perhaps a more familiar cousin is the fungus that causes the black pits in the pods of the garden beans, and particularly conspicuous upon the white pods of so-called wax varieties. In none of the other species, as far as studied, do the filaments confine themselves so strictly to the breathing pores.

Figure 9.

Anthracnose spores; those to the right are germinating.

3. LEAF BLIGHT.

(*Phyllosticta chenopodii*, Sacc.)

A third form of fungus of the spinach, quite different from the two already described, forms minute pimples in considerable numbers upon the part of the leaf attacked, usually the lower half. In Figure 10 is seen a view of the surface of a leaf that is attacked by the blight, but only a few times magnified. In size and general appearance, under the microscope, the fine threads within the leaf do not differ much from the anthracnose, but the method of spore formation is widely unlike. In the Phyllosticta the threads form a thick, brown shell, partly imbedded in the leaf, within which the small spores in vast numbers are produced. When mature and ready for dispersion they pass out through an opening at the top of the spore

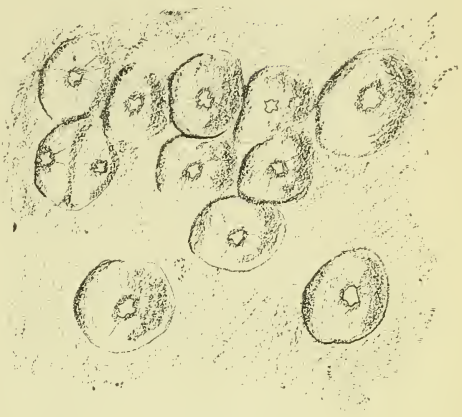

Figure 10.

Spinach leaf blight; portion of affected leaf slightly magnified.

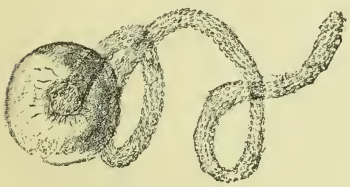

Figure 11.

Spore receptacle of leaf blight with spores shown issuing in a coil.

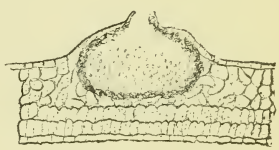

Figure 12.

A section through leaf and spore receptacle.

cavity. If a diseased leaf is moistened the spores quickly swell, and, mingled with the gelatinous substance surrounding them, pour out as a serpent-like stream in a most surprising manner. After a

time the streaming ceases, and should the leaf become dry the spores are ready to be blown about by the winds. If the water is again applied to the same leaf a new stream of spores is ejected. This is an excellent illustration of the influence of moisture and dryness upon the dispersion of spores. A spiral mass of spores held together by the attending gelatine as proceeding from the mouth of a spore cavity is shown in Figure 11. A section, through a similar receptacle, is given in Figure 12, while the colorless somewhat egg-shaped spores are shown still more highly magnified in Figure 13.

Figure 13.

Three blight spores greatly magnified.

4. SPINACH WHITE SMUT.

(*Entyloma Ellisii*, Hals.)

A member of the group of smuts, not distantly related to the smut of corn, wheat and other grains, was found upon the spinach, but, instead of having dark or purple spores, as is usual with the familiar grain smuts, they are colorless, and give the infested leaf a light appearance, as if covered with a fine frost. The attacked leaves were uniformly without the normal green color, and, of course, worthless for market. The threads of the fungus are exceedingly small, like spider filaments, and are seen with much difficulty. There are two kinds of spores; those formed within the leaf are spherical, and grouped in small clusters just beneath a breathing pore, while the second kind

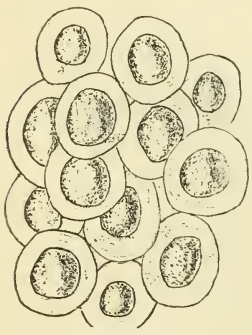

Figure 14.

A group of spinach smut spores as borne in the leaf.

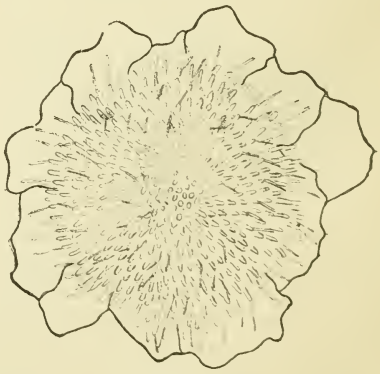

Figure 15.

A tuft of threads and conidial spores as seen above the breathing pore.

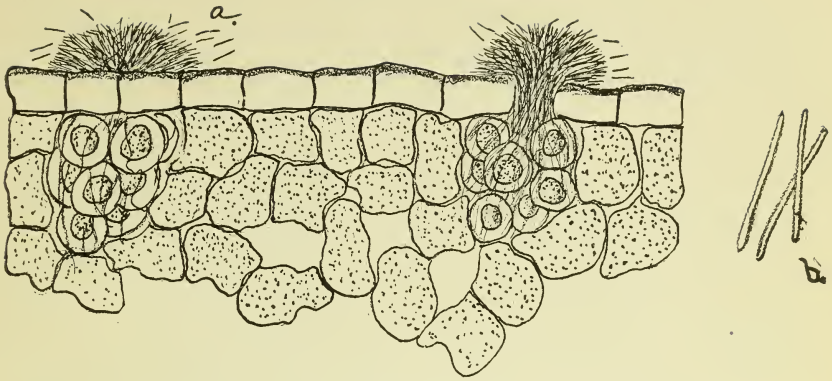

Figure 16.

Section of leaf showing the location of the smut; the conidia, *a*, more highly magnified at *b*.

are long, needle-shaped, and borne upon the ends of minute threads which pass out of each breathing pore in great numbers and form a minute tuft. Figure 14 shows a cluster of the spores as seen with a high power. This group lies in the space between the leaf cells just beneath the breathing pore. A view of a tuft of spores of the second sort, borne in the air upon the tips of threads, is seen in Figure 15, also magnified to the same extent as Figure 14. A better idea of the relation of the two kinds of spores and the minute hair-like threads is shown in Figure 16, where only a small portion of the under side of the diseased leaf is seen.

5. BLACK MOULD OF SPINACH.

(*Cladosporium macrocarpum*, Dren.)

The leaves of the spinach as they get old are quite apt to develop an abundance of a black mould that gives the general appearance shown in Figure 17, which represents a leaf much reduced in size. The dark patches are

Figure 17.

Black mould of spinach; leaf much reduced in size.

made up of numerous irregular dark filaments, Figure 18, that bear multitudes of oval spores at first colorless, but becoming brown upon reaching maturity. In many cases the spores are borne in quite regular order at the ends of the filaments, as seen in Figure 19. Other forms of the so-called black moulds were met with quite frequently, but as these are all considered as confined to leaves and other parts of plants already past their period of greatest usefulness, therefore no stress is laid upon them. Figures 20 and 21 show two conspicuous forms of the black moulds that quickly come upon the spinach leaves, most usually as found in the market, and aid materially in decay. They may be expected upon any part of plants no longer active in the processes of growth.

Figure 18.
The black mould considerably magnified.

Therefore, exclusive of the black moulds, we have considered the following four species of parasitic fungi, all of which prey upon the otherwise vigorous spinach plants, and may work together for their destruction, namely: (1) Mildew (*Peronospora effusa*, Rabenh.); (2) Anthracnose (*Colletotrichum spinaceæ*, E. & H.); (3) Leaf Blight (*Phyllosticta chenopodii*, Sacc.), and (4) White Smut (*Entyloma Ellisii*, Hals.) Two of these, the first and third, are old offenders, while the others were not discovered until the present investigations were prosecuted.

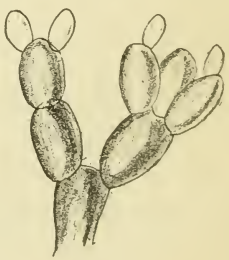

Figure 19.
One of the spore-bearing tips much magnified.

In addition to these, plants were frequently met with, the central parts of which were soft with decay, and in the tissue were found large numbers of a small worm closely related to the "vinegar eels." These worms are frequently found in gall-like

swellings of the roots of various plants, and especially those grown under glass. If they confined their work to the root it would doubtless be much less offensive, in the present case, for a spinach plant with the young central leaves decayed is not marketable.

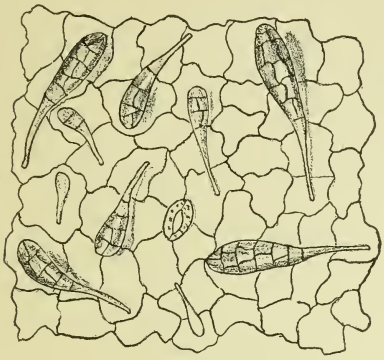

Figure 20.
Spores of a black mould.

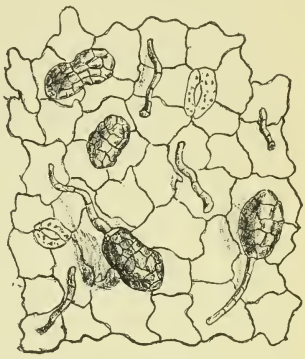

Figure 21.
Another form of black mould.

REMEDIES.

The spinach is a crop upon which remedies cannot be so readily applied as many others, because the parts attacked are the ones grown for market. Like lettuce, cabbage, and similar salad plants, the spinach cannot have its fungous enemies treated in the same way as those of the potato, sweet potato, grains or corn, fruit trees and shrubs. While it may be safe to spray grape vines with poisonous compounds, one does not like to recommend the use of the same chemicals for those plants the leaves of which go upon the table. The spinach-grower must turn his attention to the soil and seek to have it in the most healthful condition for the growth of clean plants. It is not known how long the spores of the fungi enumerated can retain their vitality. Whether for a long or a short time, it is a reasonable precaution to destroy all refuse leaves that accumulate in the beds and the assorting-house. It is a small matter to keep these leaves, loaded with thousands and millions of spores, from getting mixed with and forming a part of the soil of the hot-bed or of the soil that may afterwards be used in growing the spinach. It is not simply a matter of neatness, but of preventing or checking the decay. The worst thing to do would be to throw the diseased leaves and refuse of the spinach-bed upon the manure heap that afterwards is to

furnish the material for the hot-bed. If possible, change the location of the beds. Where the grounds cover several acres it is possible to go some distance away from the old infested beds and start upon fresh ground. It has been demonstrated with many fungi, as the smut of corn, onions, etc., that the trouble increases with the length of time the same soil is covered with the same crop. In other words, the soil becomes impregnated with the spores, and the wisest plan to pursue is the abandonment of that crop and grow others, not susceptible to the same fungi, for a few years, until the spores in the soil die from lack of conditions for growth and propagation. To these precautions it is possible to add the treatment of the soil devoted to spinach with certain chemicals that, while doing no harm to the crop, tend to rid the soil of the disease germs that may be present. It is a matter of experimentation to determine what will prove most effective for this. Equal parts of air-slaked lime and flowers of sulphur thoroughly raked into the bed might be in large measure preventive.

The most destructive fungus this season has been the anthracnose, and this, as has been demonstrated by culture, enters the leaf through the breathing pores and causes a dead patch to appear in a few days. It therefore remains to determine if some of the wild plants, closely related to the spinach, do not bear this fungus, and therefore should, if possible, be kept away. The goosefoots, sometimes called lamb's quarters, and by others pigweeds, are near of kin to the spinach, and need to be fully considered as to the fungi they bear.

With the soil in the best condition, it is possible to further use precautions by spraying the plants, when quite small, and the surrounding soil, with some fungicides that are comparatively harmless to man. With spinach carefully washed, as it should be before being cooked, there would be no serious objection in prolonging the application until the crop is safe. For this purpose hyposulphite of sodium, sulphate of potassium and sulphate of copper may be employed. As the field is new, any one wishing to make these latter tests might indicate his intentions to the Station Botanist, who will gladly assist, as far as possible, in determining the strength of the substances that the young spinach plants will bear.

CONCLUSIONS.

Spinach under glass in New Jersey has been seriously affected with fungi during the exceptionally warm and wet winter of 1889–90.

Four species of parasitic fungi have been met with in the investigation, namely: (1) a mildew (*Peronospora effusa*); (2) an anthracnose (*Colletotrichum spinaceæ*); (3) a leaf blight (*Phyllosticta chenopodii*); and (4) a white smut (*Entyloma Ellisii*), besides several species of black moulds, the most common one of which is *Cladosporium macrocarpum*.

Two of the parasitic offenders appear to be newly discovered, namely, the anthracnose and the white smut, the former being the most destructive of all. By culture it was determined to be both very contagious and rapid in its development, healthy leaves showing fully developed disease spots in six days after inoculation.

The spinach, because the whole plant is prepared for the table, is not well adapted to the application of remedies. A most important preventive measure is to burn all affected plants or parts, and not let the refuse of the bed go to the manure heap. If possible, change the location, soil, etc., of the beds, growing other crops in the old place for a few years. The soil to be used for spinach could be treated to a mixture of flowers of sulphur and air-slaked lime. With proper care salts of copper could be employed upon the young plants.

MERRILL EDWARDS GATES,
President State Agricultural College, Acting Director.

New Brunswick, N. J., July 26th, 1890.